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Estimation of the water footprint in Osmanabadi goat

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Abstract
The present study entitled "Assessment of Water Footprint in Osmanabadi Kids" was undertaken at Livestock Farm Complex, College of Veterinary and Animal Sciences, Udgir, Latur (M. S.). The experiment was conducted from zero-day to the 40th week of age in Osmanabadi kids with the daily recording of parameters during the experimental period. Total direct water consumption, direct water requirement for washing and cleaning of a shed, water consumed through milk and colostrum, and water consumed through feed and fodder in Osmanabadi kids up to the age of 40th week was found to be 926.76, 2829,138.29, and 1443.31(liters), which is 17.35%, 53%, 2.59% and 27.04 % of the water footprint of Osmanabadi kids, respectively. The water footprint in Osmanabadi kids was estimated as 5337.36 (liters) for a group of eight animals, whereas the individual water footprint per Osmanabadi goat was 667.17 (liters). Total feed intake up to the age of 40th weeks was found to be 2222.69 (Kg) from which 1443.31 (liters) of water was consumed by kids. It was found that the level of Serum Sodium, Serum Potassium, and Blood Urea Nitrogen (BUN) was increased within normal ranges in the hot and dry seasons. Considering the total waterfootprint of the Osmanabadi goat, the Osmanabadi goat is resistant to low water in tropical regions like Marathawada.

Keywords: Osmanabadi goat, water footprint, water consumption

Introduction
A water footprint shows the extent of water use in relation to consumption by people. The water footprint of an individual, community, or business is defined as the total volume of freshwater used to produce the goods and services consumed by the individual or community or produced by the business. According to the FAO (2002), food security is defined as "availability and access to sufficient, safe and nutritious (nutrition security) food to meet the dietary needs and food preferences for an active and healthy life". Food is defined as a human right. The end products for food security encompass edible agricultural crops, livestock products (meat, dairy, and eggs), freshwater fish (wild and aquaculture), wild foods (e.g., berries, mushrooms, fruits, nuts, game and bushmeat, insects) but also marine fish and seafood. For beef cattle, pigs, sheep, goats, and broiler chickens animals that provide their products after they have been slaughtered, it is most useful to look at the water footprint of the animal at the end of its lifetime, because it is this total that will be allocated to the various products (for example, meat, leather). For dairy cattle and layer chickens, it is most straightforward to look at the water footprint of the animal per year (averaged over its lifetime), because one can easily relate this annual animal water footprint to its average annual production (milk eggs). The water footprint of an individual can be calculated below

$$WF\ [a,c,s] = WF_{feed}\ [a,c,s] + WF_{drink}[a,c,s] + WF_{serv}\ [a,c,s]$$

Where, WF [a, c, s], WF feed [a, c, s] + WFdrink [a, c, s] + WFserv [a, c, s] represents the water footprint of an animal for the animal category in the country c in production systems related to feeding, drinking water and service-water consumption, respectively.

Materials and Method
Direct water consumption
a) Daily and weekly water consumption (liters)
Three times watering was carried out in a group of Osmanabadi kids. Fixed and measured quantity of water was provided to all animals and the refusal quantity was collected on the next day morning before placing fresh water in the water troughs and daily water consumption was recorded by subtracting it from the total amount of water provided to the animal. From this data, the weekly water consumption was calculated.

b) Water requirement for washing and cleaning (liters)
The water requirement for washing of shed was calculated on a daily basis by daily cleaning of sheds with the help of buckets for recording the amount of water required for washing and cleaning of the shed. In loose housing, water required for sprinkling on kachha floor to avoid dusting is also taken into consideration for the calculation of total water requirement for production purposes.

Indirect water consumption
a) Water intake through colostrum and milk (liters)
The water consumption through milk/ colostrum was recorded based on the total quantity of milk/colostrum consumed by the kid in a day. The experimental animals were fed with milk bottles during the research work up to the weaning period of the kids. The milk/colostrum consumed by the animal was recorded on a daily basis. The proportion of water was calculated on the total amount of milk/colostrum consumed by the animal. Fresh milk samples were collected at the time of milk feeding to estimate the moisture content in the milk and colostrum. After that, the samples dried in a hot air oven at 105 °C for 12 hours. The dry weight was recorded and the moisture content was calculated as per the following formulae

$$\text{Moisture content (\%)} = \frac{\text{(Fresh weight - Dry weight)}}{\text{(Fresh Weight)}} \text{ X } 100$$

The milk samples were subjected to moisture estimation in the Animal Nutrition Laboratory of College of Veterinary &Animal Sciences (COVAS), Udgir.

(b) Water intake through feed and fodder (liters)
Water consumption through feed and fodder was calculated on a daily basis. For this, an estimation of the moisture content of feed and fodder (Green, Dry, and Concentrate) was carried out which was offered to animals. The Moisture content of the feed, fodder, and grass was determined on a dry weight basis. For moisture estimation, representative samples of grass, feed, and fodder were collected from each treatment at the time of harvesting. Freshly harvested plant samples were chopped into small pieces up to 1-2 cm and weighed immediately. After that, the samples were then dried in a hot air oven at 105 °C for 12 hours. The dry weight was recorded and the moisture content was calculated as per the above formulae in same laboratory.

Total Water Requirement (liters)
The total water requirement of kids was calculated by adding average daily water consumption, indirect water intake through colostrum/milk, feed, and fodder, and average daily water required for washing and cleaning of shed and housing structures.

Daily and weekly feed and fodder intake (kg)
The main objective of the calculation of feed & fodder intake was to know the amount of feed and fodder taken by an animal which is used to estimate the actual water taken by the animal through the feed. A measured quantity of green fodder was placed in the manger, in the morning at 8.00 hours, in the afternoon at 13.00 hours, and in the evening at 17.00 hours according to the dry matter requirement of kids. A fixed and measured amount of concentrate feed was also given in the evening at 17.00 hours according to the dry matter requirement of kids in a group. The refusal quantity of feed and fodder was measured on next day morning at 8.00 hours before placing the fresh feed and fodder. The ad libitum green fodder and grasses available for feeding were DHN6, Shevri, Yeshwant, and Jaywant. The difference in quantity offered and refusal was indicated as the total feed intake of the whole group. From this data, we calculated weekly feed intake.

Results and Discussion
Direct water consumption
Average daily and weekly water consumption
Average daily and weekly water consumption (Table 1) in Osmanabadi kids was taken from zero day to forty weeks of age. Daily and weekly water consumption was found to be increased as the age of kids was increased up to 27 weeks of age, thereafter daily and weekly water consumption slightly decreased towards the 40th weeks of age, which means daily and weekly direct water consumption requirement was higher in initial weeks of age may be due to higher metabolic rates in initial age of kids. Moreover, the daily and weekly direct water consumption may be increased due to higher environmental temperature in the summer season and values are less in the monsoon and winter seasons. These findings are in relation with McGregor *et al*., (1986) [8] founda significant increase in Angora goats and Merino sheep's water intake in the summer. (Matthewan, 1993) [7] stated that an animal's water intake depends upon surrounding factors like feed consumption, metabolic rate, and ambient temperature. Ferreira *et al.* (2002) [4] stated that animals having higher metabolic mass are having higher requirement of water he found that Pedi goats had significantly (p<0.014) low intake (124.9±35.7) in relation to the Boer goats. Solanke *et al*., (2019) [10] found significant differences (p<0.05) in water intake in Deccani lambs and Osmanabadi kids also reported that water intake in Osmanabadi goats and Deccani lambs increases with an increase in environmental temperature. The environmental temperature in a barn house was lower compared to a loose type of house, which is reflected in excess water intake in animals placed under a loose housing system.

Weekly water requirement for washing and cleaning the shed
Weekly direct water for washing and cleaning (Table 1) of the shed was higher in the initial days of research work and then after water requirement for the washing of the shed slightly decreased. The highest water requirement for washing and cleaning the shed was recorded in January month and from February onwards water requirement decreased. The total water requirement for washing of shed in 1st week was 85 liters, which decreased to 64 liters at the end of work. Initially, the shed was dirty and mudded with feces on the floor, hence water required for washing of shed was increased in the initial weeks of the experiment. The water requirement for washing of shed in the loose house may be decreased due to an increase in environmental temperature in the loose house in the summer season. An increase in environmental temperature reduces moisture in the feces and it helps in keeping the floor dry. In the study, it was also found that the water requirement for cleaning the dry floor was found to be less as compared to the muddy floor with feces. The requirement for water in the months of summer had increased

due to the additional use of water for sprinkling and splashing water in mud to create dust free environment for the kids. These findings are similar in relation to Solanke *et al*., (2019) [10] who reported lower values of water requirement in the summer season.

Table 1: Direct water requirement in Osmanabadi goat

Season	Weeks	Daily Water Consumption (liter)	Weekly Water Consumption (liter)	Weekly water required for washing (liter)
Winter	1	0.00±0.00	0.00±0.00	85±1.01
	2	0.17±0.05	1.17±0.05	78±0.74
	3	0.50±0.06	3.47±0.06	79±0.89
	4	0.72±0.06	5.05±0.06	76±0.70
	5	0.79±0.06	5.55±0.06	75±0.94
	6	1.01±0.11	7.05±0.11	69±0.70
	7	1.44±0.08	10.11±0.08	77±0.49
	8	2.10±0.09	14.69±0.09	72±0.29
	9	1.88±0.1	13.14±0.1	74±0.75
Summer	10	2.30±0.16	16.09±0.16	77±0.87
	11	2.34±0.16	16.40±0.16	72±1.08
	12	2.46±0.1	17.20±0.1	81±1.48
	13	2.59±0.17	18.11±0.17	76±0.67
	14	2.58±0.14	18.08±0.14	70±0.72
	15	3.13±0.16	21.88±0.16	69±0.67
	16	3.17±0.13	22.16±0.13	70±0.69
	17	3.40±0.12	23.80±0.12	66±0.65
	18	3.83±0.11	26.78±0.11	69±0.77
	19	4.12±0.21	28.86±0.21	73±0.53
	20	4.50±0.23	31.52±0.23	70±0.76
	21	4.75±0.32	33.24±0.32	64±0.74
	22	4.72±0.09	33.06±0.09	75±0.57
Monsoon	23	5.18±0.3	36.29±0.3	66±0.69
	24	6.01±0.25	42.06±0.25	66±0.78
	25	6.35±0.21	44.42±0.21	66±0.61
	26	6.63±0.26	46.39±0.26	60±0.75
	27	4.37±0.12	30.61±0.12	71±0.70
	28	4.12±0.22	28.83±0.22	78±0.34
	29	4.32±0.22	30.27±0.22	68±0.64
	30	4.25±0.14	29.74±0.14	66±0.78
	31	4.41±0.19	30.84±0.19	69±0.77
Winter	32	4.44±0.28	31.08±0.28	66±0.81
	33	4.57±0.19	31.98±0.19	68±0.29
	34	4.37±0.2	30.59±0.2	69±1.01
	35	3.95±0.24	27.64±0.24	71±0.70
	36	3.20±0.17	22.42±0.17	70±0.79
	37	3.28±0.18	22.93±0.18	75±0.71
	38	3.59±0.17	25.15±0.17	63±0.49
	39	3.49±0.05	24.45±0.05	66±0.78
	40	3.39±0.33	23.71±0.33	64±0.67

Indirect Water Consumption

Weekly water intake through colostrum and milk

Weekly indirect water consumption through colostrum and milk (Table 2) seems to be lower in the initial weeks of age in Osmanabadi kids and it increased from the 2nd week up to the 8th week of age and then there was a slight decline from the 9th week to the 13th week of age in kids. Lower values of consumption of water in Osmanabadi kids were seen in the initial days (just after birth) may be due to a lower percentage of water in colostrum as compared to the milk, moreover, the production of colostrum from mothers is lower than the production of milk and this resulted into the small value of consumption of water through colostrum. On the other side, colostrum consumption decreased from the 2nd week and the proportion of consumption of milk increased as per the body weight of kids and this resulted in higher values of indirect water consumption through milk up to the 8th week of age. Thereafter, consumption of milk decreased from the 9th week of age as the weaning period comes to the production of milk from animals also decreased and resulting in to decrease in the consumption of milk in Osmanabadi kids. The moisture content in the milk and colostrum is similar to the findings of Bergman (1937) [2], Argüello *et al*., (2006) [1], Park (2006) [11], Rasheed *et al*., (2016) [9], Maria João Reis Lima *et al*., (2017) [6]. It has been also noticed that moisture content of milk decreases as the production of milk decreases.

Table 2: Indirect water consumption through colostrum and milk (ml) in Osmanabadi goat

Weeks	Water consumed through colostrum & milk (ml)
1	6.28±0.83
2	10.35±0.67
3	13.82±0.29
4	13.35±0.73
5	13.66±0.60
6	14.38±0.84
7	13.70±9.81
8	14.34±0.96
9	10.71±1.20
10	9.83±0.53
11	7.63±0.51
12	7.59±0.83
13	2.54±0.57

Weekly water intake through feed and fodder

Weekly water intake through feed and fodder (Table 3) was calculated based on the weekly feed intake by Osmanabadi kids. In the present study, water intake through feed and fodder was increased as feed consumption increased. Kids started eating feed from the 3rd week and thereafter consumption of feed went on increasing with the increasing age of kids. Water intake through feed increased up to the 17th week and after that, there was a decline in the water intake through feed and fodder due to reduced moisture percentage of feed and fodder in summer season. Whereas, after the completion of the summer season, water intake through feed and fodder drastically increased from the age of 29th week up to the age of 40th week. The fluctuations in the water intake through feed and fodder might be due to the environmental changes as in winter and summer seasons. There was less percentage of water in feed and fodder as compared to the monsoon season. It was also observed that, in summer season as the moisture percentage of feed reduced,dry matter in the feed increased, thus animal consumed more whole water directly. The seasonal variation of water intake through feed i.e., higher water intake through feed was noticed in the monsoon season as compared to the winter and summer season are in agreement with the findings of Ferreira *et al*., (2002) [4], who reported higher water consumption per unit feed in mutton Merino lambs than Boer goat. Solanke *et al*., (2019) [10] also found similar observations of water intake through feed and fodder in Osmanabadi kids, she reported higher water intake through feed and fodder in the loose housing system with respect to the barn housing system because of significant feed intake was found in the animals kept under loose housing system.

Table 3: Indirect water through feed and fodder in Osmanabadi goat.

Season	Weeks	Weekly water intake through feed and fodder (liter)
Winter	1	0.00±0.00
	2	0.00±0.00
	3	1.10±0.05
	4	4.97±0.10
	5	5.94±0.10
	6	7.35±0.13
	7	11.41±0.18
	8	13.12±0.23
	9	17.49±0.29
Summer	10	25.90±0.44
	11	25.66±0.42
	12	23.69±0.53
	13	15.06±0.59
	14	21.17±0.69
	15	24.91±0.66
	16	25.85±0.68
	17	20.79±0.73
	18	28.17±0.77
	19	29.53±0.82
	20	24.14±0.94
	21	30.94±0.84
	22	33.27±0.91
Monsoon	23	29.60±0.89
	24	30.50±0.92
	25	32.56±0.94
	26	31.20±1.03
	27	36.63±1.13
	28	62.28±0.99
	29	68.99±1.14
	30	68.64±1.13
	31	73.55±1.12
Winter	32	68.82±1.11
	33	67.55±1.11
	34	71.62±1.14
	35	67.36±1.19
	36	63.46±1.14
	37	70.44±1.09
	38	69.21±1.19
	39	69.64±1.09
	40	70.81±1.16

Water Footprint in Osmanabadi goats

The water footprint (Table 4) is the total volume of freshwater consumed by individual animal used to produce the goods and services. In the present study, for the calculation of the water footprint of Osmanabadi goats, we included all kinds of water consumed by animals directly and indirectly. It includes direct water consumption by animals, water consumed through colostrum, milk, feed, and fodder, and water required for washing and cleaning of sheds and premises. Total water required for direct consumption, washing and cleaning of the shed, water consumed through milk and colostrums, and total water consumed through feed and fodder were calculated as (presented in Table 4.) 926.76, 2829, 138.29 and 1443.31 (liter), respectively. Hence, the water footprint in Osmanabadi goats is estimated as 5337.36 (liter) for the Osmanabadi group, and the water footprint per individual Osmanabadi goat calculated as 667.17 (liter) up to the 9th marketable age.

Table 4: Total Water Footprint of Osmanabadi kids up to 9th month of age.

Total water requirement of a group				**Water Footprint of a Group (Liter)**
Total water requirement for direct consumption	**Total water requirement for washing and cleaning of shed**	**Total water consumed through milk and colostrum**	**Total water consumed through feed and fodder**	**5337.36**
926.76	2829	138.29	1443.31	
Total water requirement per kid				Water Footprint per kid
115.85	353.63	17.29	180.41	667.17
Percentage-wise water requirement for Osmanabadi kids				
17.35%	53%	2.59%	27.04%	

Conclusions

The daily and weekly direct water consumption may be increased due to higher environmental temperature in the summer season and values are less in the monsoon and winter seasons. Total water requirement for direct consumption, water intake through colostrum and milk, water intake through feed and fodder, and water required for washing and cleaning of the shed were estimated as 926.76 (17.35%), 138.29 (2.59%), 1443.31 (27.04%) and 2829 liter (53%) for Osmanabadi goat up to 9th months of age. Most of the water (53%) was utilized for cleaning and washing of the shed. The water footprint of an Osmanabadi goat in a group is estimated as 5337.36 (liters) and the water footprint per individual Osmanabadi goat was estimated as 667.17 (liters) up to the marketable age. The total water requirement of Osmanabadi kids was higher in the summer season followed by monsoon and winter. Water footprint in individual Osmanabadi goat is estimated as 667.17 (liter) up to the marketable age.

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Conflict of Interest

Authors hereby declare that there is no conflict of interest with regard to the data presented and the overall manuscript.

Institutional Animal Ethics Committee permission was not required for the present work.

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